

**Current Synthetic and Systems Biology** 

Open Access

# Psyllium Mucilage and Its Use in Pharmaceutical Field: An Overview

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#### Abstract

Plantago psyllium mucilage or Plantago psyllium ovate is a food grade natural polysaccharide obtained from Plantago psyllium and its mucilage is calm of natural arabinoxylan (arabinose 22.6% and xylose 74.6%). Psyllium mucilage is extracted from psyllium husk. Graft copolymerization is one of the best methods for modifying psyllium, which impart certain functional properties to psyllium without destroying its basic properties. The grafting is initiated through the formation of the free radical centers on the polymer backbone. Psyllium has wide application in many health problems, particularly cholesterol control, colon cancer prevention, high sugar levels in blood and widely used as a laxative.

Keywords: Psyllium mucilage; Husk; Seed; Laxative; Cancer

## Introduction

Psyllium husk is obtained from the seed of the *Plantago ovate* plant. Psyllium is also recognized as ispaghula and isabgol widely used as a laxative. Isabgol comes from the Persian words as band ghoul, meaning "horse flower" which is descriptive of the shape of the seed [1-6]. The plant of isabgol is generally 10 to 18 inches in height, with numerous small and white flowers are shown in (Figures 1 and 2). Normally, psyllium is cultured for its mucilage content, which is a white fibrous material with hydrophilic characteristic. The mucilage can be obtained by mechanical milling/grinding, and is usually referred to as husk [7]. Psyllium is the commonly used word for more than 200 species of the plant genus Plantago which are used commercial manufacturing of mucilage. Plantago psyllium and Plantago ovata are shaped commercially in many European countries, the former Soviet Union and various region of middle Asia. Plantago seeds popular as black, Spanish or French in trade market. Psyllium is obtained from Plantago psyllium and Plantago arenaria [8,9]. Psyllium was an indigenous plant of Persia, currently grown in the western states of India. Gujarat, Rajasthan, Madhya Pradesh, Haryana is main crop psyllium producing states in India. Currently, India is the chief producer as well as exporter of Isabgul husk and Psyllium husk in world. The crop of psyllium is mainly cultivated in Gujarat, Madhya Pradesh and Rajasthan. Among these states, Gujarat is the main center for the production as well as processing, because the environmental conditions of the Gujarat. Rajasthan also has similar status for cultivation and production as



Figure 1: Plantago ovata plant.



Figure 2: Psyllium seed.

the environmental conditions are very conducive for harvesting of these crops. Gujarat and Rajasthan are collectively reported to have an area of about 61,000 hectares under its cultivation [10,11]. India provides main contribution for availability of the psyllium in the world market and USA being the world's largest importer of psyllium husk. Some well-known psyllium global brand names are Meta-mucilage, fiber all, bonvit, konsyl, modane bulk powder, perdiem fiber, serutan, siblan, fybogel. Psyllium husk has long history of its use as traditional and herbal medicines in the Middle East, United States, Europe, India and China. Psyllium is anionic polysaccharide of L - arabinose, D - xylose and D - galactoronic acid. The husk of *Plantago psyllium* used as the raw material to obtain the psyllium mucilage shown in Figure 3, and used after purification. Its purification is carried out by precipitation in aqueous solution with alcohol and it was finally washed with acetone and dried [12,13]. Psyllium is a natural polysaccharide

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Received May 18, 2017; Accepted August 08, 2017; Published August 11, 2017

Citation: Kumar D, Pandey J, Kumar P, Raj V (2017) Psyllium Mucilage and Its Use in Pharmaceutical Field: An Overview. Curr Synthetic Sys Biol 5: 134. doi:10.4172/2332-0737.1000134

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carried out from *Plantago psyllium* and its mucilage is consisting of arabinoxylan (arabinose 22.6%, xylose 74.6%). The physiologically reactive component of Psyllium husk is exhibit to be a greatly branched arabinoxylan [14,15].

Kumar and Kaith studied Plantago afra (Plantago psyllium), Plantago ovata and Plantago indica (Plantago arenaria) belongs to the family Plantaginaceae and are also used in medicinal since ancient time. It is widely used as a home medicine in all cultures, in many types of diseases, situations like diarrhea, as bulk forming, chronic constipation, non-irritant laxative drug, inflammation of the mucous membrane of gastro intestine and genitourinary tracts, gonorrhea, duodenal ulcer, piles, demulcent as a cervical dilator etc. [1,16,17] Marlett and Fischer investigated that in contrast to arabinoxylans in cereal a grain that is extensively fermented, psyllium husk have a structural application, as yet unidentified, and that hinders its fermentation by typical colonic micro flora [18]. Gupta and Fischer et al. [19,20] investigated that Psyllium has a powerful capacity to obtain a gel in water and through animal and human feeding experiments, so psyllium is a mucilaginous fiber. Psyllium has been exhibiting that a gel producing fraction, amounting to some 55% to 60% of the psyllium husk which is responsible for both the cholesterol lowering activities and laxative. Viscous, non-nutrient polysaccharides, like as β-glucans as well aspectins, low blood cholesterol levels through the similar mechanism as psyllium, but these substances have negligible effects on bowel function. Anderson et al. [21] studied the structure of the arabinoxylan showed in Figure 4. Plantago psyllium is a significant herb that has been used in health care for various centuries in South Asia. It is widely used in medicinal characteristics all over the world. Psyllium an ayurvedic herb is found in Iran, India and Afghanistan. It is also native to the surrounding of the Mediterranean, including Northern Africa, Europe and Pakistan. This plant can be grown under a wide range of the arid areas of the world due to its low water requirement. Psyllium husk is a







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Figure 6: Scanning electron microscopy image of Psyllium mucilage.

bulking fiber, after ingestion it expands and forms gelatin like mass in the colon by drawing in water. Once this occurs, the husks are able to "undergrowth" the bowels clean and transport waste by the stomach tract. Some population based studies also recommend that enhanced fiber consumption may decrease the risk of colon cancer. Psyllium husk is valued for its nutraceuticals, medicinal and pharmaceuticals applications. It is mostly treated such as laxative, which have a plethora of health benefits and has established to be actual in treating irritable, constipation, diabetes, bowel syndrome, high cholesterol, colon cancer, obesity, atherosclerosis and ulcerative colitis among several other health conditions [20].

# **Characterization of Psyllium**

#### FT-IR spectroscopy

Kaith and Kumar [22] investigated that the spectra of Psyllium has broad absorption band at 3401 cm<sup>-1</sup> which can be credited to -OH stretching of alcohol (Figure 5). A peak seeming at 2926 cm<sup>-1</sup> is due to C-C stretching of alkanes, while the peak at 1050 cm<sup>-1</sup> credited to C-O-C stretch of ether. The peaks showing at 896, 714 and 613 cm<sup>-1</sup> may be due to polymer chain bending.

#### Scanning electron microscopy

Sen et al. [23] studied the surface morphology of psyllium they were analyzed in scanning electron microscopy (SEM) in powdered form (Model: JSM-6390LV, Jeol, Japan). the Surface morphology of psyllium they were analyzed in scanning electron microscopy (SEM) they were found psyllium has smooth and homogenous structure shown in Figure 6.

#### Thermo-gravimetric analysis and differential thermal analysis

Thermo gravimetric analysis of Psyllium in different conditions was carried-out as a function of percent weight loss versus temperature



at a rate of 10°C/min in N<sub>2</sub> (Figure 7). The analysis was performed to examine the changes in the thermal properties of the Psyllium brought about by graft copolymerization with acrylamide and acrylic acid in different reaction conditions studied by Kumar et al. [24].

#### Psyllium act as a drug delivery carrier

Psyllium belongs to Plantago ovata family of plants. Psyllium seeds as well as husk are widely used in pharmaceutical field as demulcent, emollient laxative, drug therapy on lipid and glucose levels and many other diseases. Many drug delivery devices have been investigated to deliver the drug for therapy, but hydrogels, particularly based on natural polymer, have attracted considerable attention as excellent candidates for controlling release devices or targetable devices of the therapeutic agents. Singh and coworker investigated that Psyllium itself also acts as anti-ulcer agent as well as release of rabeprazole from the drug laden hydrogels may increase the curing potential of the drug delivery device. The haemo compatibility was assessed by learning the blood connections with graft copolymer with reference to thrombogenicity as well as haemolytic potential. Thrombogenicity results specify that graft copolymers are non-thrombogenic as the weight of clot shaped and thrombus percentage for graft copolymer was less than the positive control [14,22,25]. Psyllium is one of the medicinally important gels forming glucose dropping dietary fiber. It reduces hyperglycemia in diabetes by inhibition of intestinal glucose absorption as well as improvement of motility. Since the glucose lowering effect of psyllium was clearly evident when simultaneously administered with glucose, reserve of glucose absorption in the instinctive is a likely contributor to the mechanism of action. Psyllium in the diet also develops glucose broadmindedness in diabetes; it has been described for the action of constipation, diarrhea, and inflammation bowel diseases-ulcerative colitis, obesity in children, adolescents and high cholesterol. In view of the pharmacological significance of psyllium polysaccharides to decrease glucose absorption as well as drug delivery strategies based on hydrogels, psyllium, if appropriately tailored to synthesize the hydrogels, can work as the double potential candidates to improve new drug delivery systems [15,26]. In one study the biochemical, nutritional and hematological effects of psyllium has been unshaken. Ispaghula was observed that a daily dose of 11.5 g of ispaghula was well tolerated and the mainstream of opposing events recorded were minor, of short duration and either unconnected or perhaps related to the study treatment. The results from the study suggested that Plantago psyllium ovata could be used with sureness for the long-term action of mild-tomoderate hypercholesterolemia studied with Oliver and coworker [27]. US Food and Drug Administration recently authorized the use of health claims on food products containing soluble fiber from psyllium which associated with a decreased risk of coronary heart disease studied by Anderson et al. [26].

# Synthesis Polymer Matrix of Psyllium

Graft and crosslink materials of Psyllium were prepared by free radical polymerization mechanism and microwave irradiation method.

- 1. Free radical mechanism.
- 2. Microwave irradiation methods.

## Free radical mechanism

Polymeric networks of Psyllium were prepared by the free radical polymerization mechanism in the presence of crosslinker, because crosslinker generate the reactive sites and these active sites can be related both with the radical on the psyllium as well as monomers and form of three-dimensional networks, which were widely used to study the *in vitro* release of the model drugs. The reaction was carried out with a specific amount of psyllium mucilage, initiator, monomer and crosslinker, in the specific solvent at 50°C temperature for 1-2 h. The final product was precipitated (ppt) in excess of isopropanol and filtered by a sintered glass filter. The ppt was again inaudible in acetone shadowed by filtration and finally the precipitate was dried in oven at 40°C. The homopolymer was removed from the grafted copolymer by using acetone as solvent in a soxhelet extractor until a constant weight was obtained [27].

## Microwave irradiation methods

Microwave irradiation is used most efficaciously to improve the procedural limitation in the synthesis of a range of graft modified polysaccharide material. In fact, the increasing interest in green and clean eco-friendly chemistry has interested the use of microwaves in the polysaccharide grafting modification. Thus, microwave irradiation meaningfully reduced the use of poisonous solvents as well as the reaction period in mostly the grafting reaction of interest here, ensuring high yields product selectivity and cleans product formations [28].

# **Drug Delivery Studies**

An extensive diversity of grafted natural polymer psyllium has been used to fabricate in different types of drug delivery system. Among these, colon under bout drug delivery systems have attracted several researcher's due to the separate benefits they current such as near neutral pH, longer transportation time and decreases enzymatic activity. Moreover, in recent studies, colon specific drug delivery systems are ahead significance for use in the action of local pathologies of the colon and also for the universal delivery of protein as well as peptide drugs, Singh et al. investigated, that more colonic concentration of drugs is compulsory for the treatment of the diseases related with the colon. Therefore, a flexible approach is desirable to deliver drugs to the colon for effective therapy. Singh and Sharma et al. also studied that the development in drug therapy is a significance of not only the project of new drug molecules but also the growth of appropriate drug delivery systems. The traditional drug delivery systems do not provide an ideal pharmacokinetic profile, particularly for the drugs, which display high poisonousness and fine therapeutic window. In an ideal case scenario, such a profile can be attained by use of the natural polysaccharides matrix which delivers controlled delivery of drug to preserve the therapeutic level. Among different hydrogels, drug delivery devices, especially based on polysaccharides have concerned considerable attention as a better candidate for controlling release of therapeutic agents [29]. Singh, et al. Studied the modified psyllium with acrylic acid based graft copolymer also used in colon precise drug delivery [30]. The dynamics of model drugs (tetracycline hydrochloride, insulin

Curr Synthetic Sys Biol, an open access journal ISSN: 2332-0737

and tyrosine) were leased from modified psyllium with acrylic acid drug loaded hydrogels, the Crosslink copolymer used in colon exact drug delivery. The released of water-soluble drug entrapped in a hydrogels, befallen only after water penetrate the network to swell the polysaccharides and dissolved the drug, followed by diffusion along the aqueous pathways to the surface of the device. The release of the drug was closely linked to the swelling characteristics of the graft copolymer, which in turn, was a key function of chemical architecture of the graft copolymer. Tetracycline hydrochloride was released from per grams of the drug-loaded hydrogels were investigated in different release medium, the amount of drug release increased in pH 7.4 buffer was higher than and distilled water and pH 2.2 buffer. In pH 2.2 buffers higher amount of release may be more due to the solubility of the drug in this medium was expected. The drug was released quicker in pH 7.4 buffer. Insulin and tyrosine were released from the polymer matrix, the amount of insulin and tyrosine released per gram of the gel was higher in distilled water and pH 7.4 buffers as compared to the pH 2.2 buffer. This observation was explained on the basis of the swelling of the hydrogels. Fifty percent of the total release of the drug occurred in respectively in releasing medium of pH 7.4 buffers, pH 2.2 buffer and distilled water. This observation was very significant for emerging the colon specific drug delivery systems and it was observed from the rate of release and release trends that the release of insulin was occurring only at higher pH which corresponds to the colon studied by Singh et al. in 2007 [31]. Singh et al. [32] in 2008 studied the dynamics of model drug anticancer 5-fluorouracil was released from psyllium and polyacrylic acid polymeric networks. It was also investigated that from the swelling and drug release in the different pH buffer that the graft copolymer was pH responsive and could be oppressed for the delivery of anticancer drug to the colon. The effect of pH on the release profile of 5-fluorouracil was studied in varying the pH of the release medium. The drug was released from per gram of the drug-loaded hydrogels; the amount of drug released in the pH 7.4 buffers and in distilled water was more as compared to the pH 2.2 buffer. This observation was corresponding to swelling trends observed in different pH medium [32]. Singh et al. [33] reported that the tetracycline hydrochloride drug and dynamics of model antibiotic drug rifampicin were released from the modified psyllium with methacrylamide through radiation crosslinked polymerization. The release dynamics of rifampicin was a broad-spectrum antibiotic used to treat Mycobacterium contagions, leprosy and with tuberculosis and also has a role in the handling of methicillin-resistant Staphylococcus aureus in combination with fusidic acid. It was used in prophylactic therapy against Neisseria meningitidis (meningococcal) infection. It was also used to treatment of infection through Listeria species, Legionella pneumophila, Haemophilus influenza and. Neisseria gonorrhoeae Rifampicin prevents DNA-dependent RNA polymerase in bacterial cells by required to its beta-subunit, thus stopping transcription of mRNA and successive translation to proteins. However Rifampicin did not quandary to mammalian nuclear RNA polymerase and therefore does not affect the RNA synthesis in human beings. Rifampicin was also known for its potent effect and ability to prevent drug resistance. It rapidly kills fast-dividing bacilli strains as well as "persisters" cells, which was remained biologically unreactive for long periods of time that permit them to avoid antibiotic activity. The amount of drug was released at pH 7.4 buffer was more as compared to the pH 2.2 buffer. Hydrogels consist of macromolecular chains cross linked to each other to create entangled mesh structure, providing a matrix for entrapment of drugs. When such loaded matrix comes in contact with thermodynamically companionable solvent, relaxation of polymeric backbone takes place. The liquefied drug diffuses into the external discharging medium. More the swelling, faster the release of drug from the polymer matrix will occur [33]. Singh et al. [34] studied that the tetracycline hydrochloride drug was released from the improved psyllium with methacrylamide poly (MAAm) polymeric networks through using N,N-MBAAm as cross-linker and ammonium persulfate (APS) as initiator which used in colon specific drug delivery. The release of water-soluble drug tetracycline hydrochloride obtained only after water penetrates the polymeric networks to swell and dissolve the drug, tracked by diffusion along the aqueous ways to the surface of the device. The effect of pH on the release pattern of tetracycline was studied in varying the pH of the release medium. However, the amount of drug release in pH 7.4 buffer solutions was higher than the pH 2.2 buffer and distilled water. Singh, et al. [35] observed that dynamics model of the drug tetracycline hydrochloride was also released from the modified polysaccharide psyllium with 2-hydroxylethylmethacrylate (2-HEMA) and acrylamide (AAm)-based polymeric networks.

Singh and Sharma studied that the model of antibiotic drug tetracycline hydrochloride was also released from the modified psyllium with poly (vinyl alcohol) and poly(acrylic acid) in different release medium at 37°C was observed more in pH 2.2 buffer, hence these hydrogels were suitable for peptic ulcer caused by helicobacter pylori. The release of antibiotic drug tetracycline hydrochloride from the drug loaded polymer was more observed in pH 2.2 buffer solution [36]. Singh et al. were prepared Psyllium-PVA hydrogels by chemical method, which release profile of the rabeprazole sodium in different release medium at 37°C. The amount of drug released in pH 7.4 buffer was higher than the release in pH 2.2 buffer solution. More release of drug in pH 7.4 buffer may be due to higher swelling of hydrogels, and higher solubility and stability of rabeprazole sodium under alkaline conditions. Thrombogenicity of psyllium-cl-PVA hydrogels clot formed and thrombus percentage for polymers were  $0.275 \pm 0.019\%$ , gram per 2 ml of blood and  $91.58 \pm 6.75\%$ , respectively. It was observed that clot formation was inferior in the membranes than in the governor and for this reason, the polymers were classified as non-thrombogenic. The hemolytic potential of psyllium-cl-PVA The hemolytic percentage of hydrogen was found to be  $4.51 \pm 0.37\%$ . Psyllium-cl-PVA hydrogel having haemolytic percentage between 2 and 5% was found to be partially haemolytic [37]. The release dynamics of the classical drugs (salicylic acid and tetracycline hydrochloride) was synthesized by psyllium with polyacrylamide (AAm) based hydrogels. Salicylic acid and tetracycline hydrochloride were released from per grams of the drug loaded hydrogels. The quantity of drug release in pH 7.3 buffer was higher than the release medium of 2.3 pH buffer and distilled water [38]. Water-soluble drug salicylic acid and tetracycline hydrochloride was also released from the modified psyllium with N-Hydroxymethylacrylamide (N-HMAAm) based hydrogels. The release of the drug was closely related to the swelling characteristics of the hydrogen. Salicylic acid tetracycline were in releasing medium of pH 7.3 buffer, pH 2.3 buffer and distilled water [29]. Kumar, modified Psyllium (Psy) with acrylamide (AAm) based superabsorbent; hydrogels were applied for controlling delivery of 5-amino salicylic acid under different pH conditions at 37°C. Psy-cl-poly (AAm)-IA was found to exhibit maximum initial release of drug at pH 9.2 (218  $\pm$  6.55 ppm) followed by the release at pH 7.0 (185  $\pm$  2.09 ppm) and release at 4.0 pH (109 ± 5.51 ppm). Moreover, final release of drug was found maximum in case of alkaline medium (301 ± 7.24 ppm) followed by release in neutral medium (291  $\pm$  7.20 ppm) and then in acidic medium (257  $\pm$  14.10 ppm). The maximum release of drug was found to increase with increase in pH [24]. Prashar, et al. investigated that Psyllium cross-linked with poly acrylic acid (AA) was used for stimulus sensitive drug delivery system as an effective and an alternate



drug carrier in comparison to artificial backbone based polymers. The electrical stimulus studies were carried using alternative current (AC) source. The swelling behavior of candidate polymer was estimated using artificial biological fluid. Maximum swelling was found in artificial biological fluid. Initially a rapid swelling was reported in the candidate synthetic polysaccharides, which might be because of the detail that the solvent system on electrolysis dissociate into ions which easily made an entrance into the gel network and swelling was observed [38].

# Use of psyllium in pharmaceutical field

*Plantago psyllium* mucilage or *Plantago psyllium ovata* is a food grade polysaccharide. It has soluble fiber component. Psyllium has wide application in many health problems. Many researchers have investigated amazing health benefits of psyllium mucilage particularly cholesterol control, preparation for colonoscopy procedure, increasing absorption of water during ingestion subsequent to relaxed stools and reduced pain associated with hemorrhoids, colon cancer prevention, high sugar levels in blood, obesity and weight loss, inflammatory bowel disease, and widely used as laxative etc. (Figure 8).

#### Reduced the cholesterol levels

Anderson et al. studied, psyllium is widely used to reduce the cholesterol levels. It is a widely accepted statement that elevated plasma cholesterol level is a major factor leading to the development of several lethal diseases, such as cardiovascular disease (CVD) and coronary heart disease (CHD). Although medical technologies improved rapidly in the past many years, CHD is still the leading cause of death in the US and other western countries. They were also investigated that there is a positive association with plasma LDL cholesterol levels and coronary heart disease risk. Intake of dietary fibers known to lower the concentration of LDL in plasma is considered to be highly beneficial. Psyllium drinking has consistently shown significant reductions in plasma LDL cholesterol levels ranging from 10 to 24%. Reports the utility of psyllium, mainly in hypercholesterolemia men, have suggested that it lowers serum cholesterol as an outcome of the binding of bittering acids in the stomach lumen and abridged risk of coronary heart disease. The mechanism of action of psyllium's hypercholesterolemia effects has not been completely elucidated [39,40].

# Diabetes

Brennan studied, that that psyllium may serve as a hypoglycemic

agent in healthy human subjects as well as patients with diabetes. It helps control the rise of blood glucose following a meal. They suggested moderate decreases in blood sugar levels after a single quantity of psyllium, with unclear long-term effect [41]. Water soluble nutritional fibers, reduction postprandial glucose concentrations and decrease serum cholesterol concentrations in men with type -2 diabetes. Initial or unrestrained studies suggested that psyllium improved glycemic and lipid control in individuals with type -2 diabetes. The capacity of soluble fibers to decrease the postprandial glucose reaction to meals eaten some hours after fibre ingestion (second meal effect) was shown previously in non-diabetic individuals. It also reduced insulin recruitment in patient with diabetes mellitus [32,42].

## **Cancer prevention**

Sierra et al. investigated that psyllium has anti-carcenogenic characteristics, especially for breast cancer and colon cancer. Psyllium is used to increase the bulk of stool and reduced the time of transits and also reduced the revelation of the intestinal wall to the deadly compounds, which is found in the stool. Although the underlying mechanisms of psyllium is cancer prevention capability are still not thoroughly clear, a large body of research has been done to reveal the possible effects [32,43].

# Laxation

Many researchers have investigated that psyllium is widely used as a laxative. In many years, psyllium has been used as an effective action towards irritable bowel disease due to its laxative effect. They also study has been conducted to measure the effectiveness of psyllium, and the results were seen to be combined. Kumar et el. Studied, similar effect of psyllium on ameliorating bad-tempered bowel syndrome. They observed that the optimum dosage of psyllium for this treatment using three different doses: 10 g, 20 g and 30 g daily. The observation was divided into two parts. In part first, patients were administered 10 g psyllium every day for 17 days, and then the dosage increased to 20 g for the subsequent 17 days and finally, 30 g psyllium were given to patients daily for the last 17 days. In part II, to avoid the potential spill over from single dose to the next one, three different dosages of psyllium were administered in a random order and a one-week washout period was included between the two dosages [17]. By clinical assessments of irritable bowel syndrome in patients, a dosage of 20 g psyllium per day was postulated to be the optimum dosage. The laxative effect of psyllium was considered to be mainly due to its water soluble and gelforming capacity [44].

# Constipation

The efficiency of fiber and psyllium in exacting, on constipation depends on the chief cause of the constipation. In a study of 50 patients 70 research papers with chronic constipation, the consumption of 10-30 grams daily of a psyllium seed grounding provided bowel relief in 80 percent of participants who had no known pathological cause for their constipation. Only 15 percent of persons with slow shipment responded to psyllium. A slightly greater percentage (40%) of those with disorders of defecation-including reconciling internal prolapse, anismus, and rectal hypersensitivity-found development.

# Hemorrhoids

On the basis the study of many research paper the benefit of psyllium for constipation as well as loose stools, it is not astonishing it would also be of benefit for hemorrhoids. Individuals in the psyllium had major development in reduction of hemorrhage and a dramatic decrease of congested hemorrhoidal cushions. Bleeding on making contact with stopped after action in the psyllium, while those in the control skilled no difference. It also appear psyllium action for this problem must be done for a minimum of one month and fifty, as a study of 45-days fiber supplementation unsuccessful to show development; whereas, when taken for 50 days major improvement was noted [6].

#### Side effects of psyllium

Many researchers have investigated that a daily dose of 15 g of psyllium was well tolerated as well as the majority of unpleasant events recorded were minor, for minimum and either unconnected or perhaps related to the study behavior. They were also observed that psyllium husk could be used with self-assurance for treatment of mild-tomoderate hypercholesterolemia. U.S. Food and Drug Administration now authorized the use of health claims on food products from psyllium that state that they were connected with a decreased danger of coronary heart disease. The addition of isabgole to traditional nourishment for people with diabetes is safe, is well tolerated, and improves glycemic and Lipid control in men with type diabetes and hypercholesterolemia [45].

#### Conclusion

Psyllium is a natural polysaccharide obtained from *Plantago psyllium* and its mucilage is composed of natural arabinoxylan (arabinose 22.6%, xylose 74.6%). Mucilage is a non-toxic biomaterial, and abundantly found in nature. It has a typical combination of biological activity with mechanical and physical properties, chemical modification, and can convert them into various derivatives. Graft/cross linked copolymerization is a exclusive method among the techniques for improve natural polymers mostly polysaccharides. Graft/ crosslinked copolymerization is an effective method to incorporate desired properties in the available polymer backbone, and these are useful in many applications in diverse fields. This unique characteristic makes them in important bio material for biochemical and pharmaceutical applications.

#### References

- Kumar D, Chandra R, Dubey R (2016) Synthesis and characterisation of cross-linked polymers of acrylic acid and psyllium mucilage (Psy-cl-AA). J Technological Advances and Scientific Res 2: 185-189.
- Rao MR, Babrekar L, Kharpude VS, Chaudhari J (2017) Synthesis and characterization of psyllium seed mucilage grafted with N, N-methylene bisacrylamide. Int J Biol Macromolec 103: 338-346.
- Ricklefs-Johnson K, Johnston CS, Sweazea KL (2017) Ground flaxseed increased nitric oxide levels in adults with type 2 diabetes: A randomized comparative effectiveness study of supplemental flaxseed and psyllium fiber. Obesity Medicine 5: 16-24.
- Sukhija S, Singh S, Riar CS (2016) Analyzing the effect of whey protein concentrate and psyllium husk on various characteristics of biodegradable film from lotus (*Nelumbo nucifera*) rhizome starch. Food Hydrocoll 60: 128-137.
- Yu L, Yakubov GE, Zeng W, Xing X, Stenson J, et al. (2017) Multi-layer mucilage of Plantago ovata seeds: Rheological differences arise from variations in arabinoxylan side chains. Carbohydr Polym 165: 132-141.
- Nayak BR, Singh RP (2001) Development of graft copolymer flocculating agents based on hydroxypropyl guar gum and acrylamide. J Appl Polym Sci 81: 1776-1785.
- Romero AL, West KL, Zern T, Fernandez ML (2002) The seeds from Plantago ovata lower plasma lipids by altering hepatic and bile acid metabolism in guinea pigs. J Nutr 132: 1194-1198.
- Praznik W, Čavarkapa A, Unger FM, Loeppert R, Holzer W, et al. (2017) Molecular dimensions and structural features of neutral polysaccharides from the seed mucilage of *Hyptis suaveolens* L. Food Chem 221:1997-2004.
- Rao MR, Warrier DU, Gaikwad SR, Shevate PM (2016) Phosphorylation of psyllium seed polysaccharide and its characterization. Int J Biol Macromolec 85: 317-326.

10. Janin YL (2003) Peptides with anticancer use or potential. Amino acids 25: 1-40.

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- Kennedy JF, Sandhu JS, Southgate DA (1979) Structural data for the carbohydrate of ispaghula husk ex Plantago ovata Forsk. Carbohydr Res 75: 265-274.
- Bhatia M, Ahuja M (2015) Psyllium arabinoxylan: Carboxymethylation, characterization and evaluation for nanoparticulate drug delivery. Int J Biol Macromolec 72: 495-501.
- Hosseini M, Salari M, Salari R (2015) Psyllium seed may be effective in the treatment of gastroesophageal reflux disease (GERD) in patients with functional constipation. Journal of Medical Hypotheses and Ideas 9: S4-S7.
- Pal S, Radavelli-Bagatini S, Ho S, McKay JL, Jane M (2014) Nutrition in the prevention and treatment of abdominal obesity, Academic Press, San Diego, California. pp. 505-514.
- Thakur VK, Thakur MK (2014) Recent trends in hydrogels based on psyllium polysaccharide: A review. J Clean Prod 82: 1-5.
- Mishra S, Sinha S, Dey KP, Sen G (2014) Synthesis, characterization and applications of polymethylmethacrylate grafted psyllium as flocculant. Carbohydr Polym 99: 462-468.
- Kaith BS, Kumar K (2007) Preparation of psyllium mucilage and acrylic acid based hydrogels and their application in selective absorption of water from different oil/water emulsions. Iran Polym J 16: 529.
- Marlett JA, Fischer MH (2003) The active fraction of psyllium seed husk. Proc Nutr Soc 62: 207-209.
- Gupta RR, Agrawal CG, Singh GP, Ghatak A (1994) Lipid-lowering efficacy of psyllium hydrophilic mucilloid in non-insulin dependent diabetes mellitus with hyperlipidaemia. Indian J Med Res 100: 237-241.
- Fischer MH, Yu N, Gray GR, Ralph J, Anderson L, et al. (2004) The gel-forming polysaccharide of psyllium husk (Plantago ovata Forsk). Carbohydr Res 339: 2009-2017.
- Anderson JW, Allgood LD, Turner J, Oeltgen PR, Daggy BP (1999) Effects of psyllium on glucose and serum lipid responses in men with type 2 diabetes and hypercholesterolemia. Am J Clin Nutr 70: 466-473.
- Kaith BS, Kumar K (2008) Vacuum synthesis of psyllium and acrylic acid based hydrogels for selective water absorption from different oil–water emulsions. Desalination 229: 331-341.
- Sen G, Mishra S, Rani GU, Rani P, Prasad R (2012) Microwave initiated synthesis of polyacrylamide grafted Psyllium and its application as a flocculant. Int J Biol Macromolec 50: 369-375.
- Kumari A, Kaith BS, Singha AS, Kalia S (2010) Synthesis, characterization and salt resistance swelling behavior of psy-g-poly (AA) hydrogel. Adv Mater Lett 1: 123-128.
- Singh B, Chauhan N, Kumar S, Bala R (2008) Psyllium and copolymers of 2-hydroxylethylmethacrylate and acrylamide-based novel devices for the use in colon specific antibiotic drug delivery. Int J Pharm 352: 74-80.
- 26. Singh B, Kumar S (2008) Synthesis and characterization of psyllium-NVP based drug delivery system through radiation crosslinking polymerization. Nucl Instrum Methods Phys Res B: Beam Interactions with Materials and Atoms 266: 3417-3430.
- 27. Anderson JW, Allgood LD, Lawrence A, Altringer LA, Jerdack GR (2000) Cholesterol-lowering effects of psyllium intake adjunctive to diet therapy in men and women with hypercholesterolemia: meta-analysis of 8 controlled trials. Am J Clin Nutr 71: 472-479.
- Singh V, Kumar P, Sanghi R (2012) Use of microwave irradiation in the grafting modification of the polysaccharides–A review. Prog Polym Sci 37: 340-64.
- 29. Singh B (2007) Psyllium as therapeutic and drug delivery agent. Int J Pharm 334: 1-4.
- Singh B, Chauhan GS, Bhatt SS, Kumar K (2006) Metal ion sorption and swelling studies of psyllium and acrylic acid based hydrogels. Carbohydr Polym 64: 50-6.
- Singh B, Chauhan GS, Kumar S, Chauhan N (2007) Synthesis, characterization and swelling responses of pH sensitive psyllium and polyacrylamide based hydrogels for the use in drug delivery (I). Carbohydr Polym 67: 190-200.
- 32. Singh B, Chauhan N, Kumar S (2008) Radiation crosslinked psyllium and

polyacrylic acid based hydrogels for use in colon specific drug delivery. Carbohydr Polym 73: 446-455.

- Singh B, Sharma V, Kumar A, Kumar S (2009) Radiation crosslinked polymerization of methacrylamide and psyllium to develop antibiotic drug delivery device. Int J Biol Macromolec 45: 338-347.
- 34. Singh B, Sharma N, Chauhan N (2007) Synthesis, characterization and swelling studies of pH responsive psyllium and methacrylamide based hydrogels for the use in colon specific drug delivery. Carbohydr Polym 69: 631-643.
- Singh B, Sharma N (2008) Development of novel hydrogels by functionalization of sterculia gum for use in anti-ulcer drug delivery. Carbohydr Polym 74: 489-497.
- Singh B, Sharma V (2010) Design of psyllium–PVA–acrylic acid based novel hydrogels for use in antibiotic drug delivery. Int J Pharm 389: 94-106.
- Singh B, Lal H, Pal L, Sharma V (2012) In vitro release profile of anti-ulcer drug rabeprazole from biocompatible psyllium-PVA hydrogels. J Mater Sci: Materials in Medicine 23: 1021-1032.
- Singh B, Chauhan GS, Sharma DK, Chauhan N (2007) The release dynamics of salicylic acid and tetracycline hydrochloride from the psyllium and polyacrylamide based hydrogels (II). Carbohydr Polym 67: 559-565.

- Chourasia MK, Jain SK (2003) Pharmaceutical approaches to colon targeted drug delivery systems. J Pharm Pharm Sci 6: 33-66.
- 40. Singh B, Bala R (2014) Polysaccharide based hydrogels as controlled drug delivery system for GIT cancer. Int J Biol Macromolec 65: 524-533.
- Brennan CS (2005) Dietary fibre, glycaemic response, and diabetes. Mol Nutr Food Res 49(6): 560-570.
- 42. Clark C, Gardiner J, McBurney M, Anderson S, Weatherspoon L, et al. (2006) Effects of breakfast meal composition on second meal metabolic responses in adults with type 2 diabetes mellitus. Eur J Clini Nutr 60: 1122-1129.
- Sierra M, García JJ, Fernández N, Diez MJ (2001) Effects of ispaghula husk and guar gum on postprandial glucose and insulin concentrations in healthy subjects. Eur J Clin Nutr 55: 235.
- 44. Bliss DZ, Jung HJ, Savik K, Lowry A, Le-Moine M, et al. (2001) Supplementation with dietary fiber improves fecal incontinence. J Res Nurs 50: 203-213.
- 45. Anderson JW, Davidson MH, Blonde L, Brown WV, Howard WJ, et al. (2000) Long-term cholesterol-lowering effects of psyllium as an adjunct to diet therapy in the treatment of hypercholesterolemia. Am J Clin Nutr 71: 1433-1438.

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